# APPENDIX C

# TTY Forum

## Seeking Solutions to TTY/TDD Through Wireless Digital Systems
## TTY/TDD FORUM - 7

## Final
(October 1998)

September 8 & 9, 1998
Washington, DC

# AGENDA

| Forum Goal: *Seeking Solutions to TTY/TDD Through Wireless Digital Systems* | |
|---|---|
| 1. Call to Order & Opening Remarks | Co-Chairs, CTIA/PCIA |
| 2. Introductions and Attendance Roster | |
| 3. Call for and Numbering of Contributions | |
| 4. Review & Approve Agenda | |
| 5. Review & Approve TTY Forum – 6 Summary | |
| 6. Review TTY Forum Correspondence | |
| 7. TTY Liaison Reports Updates: *FCC; CTIA; NAD; TDI* | Appropriate Reps |
| 8. Review /Modify / Amend TTY Forum *Agreements* | |
| 9. Analog Phones and Devices List | CTIA |
| 10. Range Star Presentation | |
| 11. Working Group Reports<br><br>• Working Group #1/3: TTY via Vocoder and Coupling.<br>• Through Put Testing<br>• Update Matrix<br>• Review Draft SRD - 2.5mm jack<br>• Working Group #2: TTY via Data Services<br>• Review and Discuss Draft SRD | Wesley Howe<br><br><br><br>Lee Whritenour<br>Brad Blanken, Chair |
| 12. Standardized Testing and Final Evaluation | |
| 13. FCC Extension Request Process | |
| 14. Consumer Requirements Document | |
| 17. New Business/Next Steps. | |
| 18. Next Meeting | |
| 19. Adjournment | |

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# 1. CALL TO ORDER & OPENING REMARKS

Welcome and opening remarks were given by co-chair, Ed Hall, CTIA. The October deadline is approaching and the test results have not been overwhelmingly encouraging. A large portion of this meeting will be devoted to testing and identifying solutions. It is the chair's opinion that the TTY Forum is a group of stakeholders gathered to provide the manufacturers with feedback to identify what consumer and industry requirements are. Some have identified this group as a testing forum to establish tests and establish satisfactory performance of equipment.

This Forum has provided recommended tests and established consumer needs for solutions. The Forum can present the results of the efforts in a finalized document to the FCC to show due diligence and identify direction of efforts.

Billy Ragsdale, Steering Committee, sees this meeting as a point where the rubber meets the road. Need to come up with a performance measure today that will give a standardized test to the manufacturers to move forward.

# 2. INTRODUCTIONS AND ATTENDANCE ROSTER

Introductions were made and the attendance roster circulated.

# 3. CALL FOR AND NUMBERING OF CONTRIBUTIONS

Contributions were submitted and numbered as follows:

| Number | Document | Agenda # |
|---|---|---|
| TTY Forum/98.09.08.01 | Agenda | |
| TTY Forum/98.09.08.02 | Appendix A   Agreements Reached at TTY Forums | 8 |
| TTY Forum/98.09.08.03 | Appendix D: Testing Completion Matrix | 11 |
| TTY Forum/98.09.08.04 | Appendix C:Issue Statements | 8 |
| TTY Forum/98.09.08.05 | CTIA letter | 14 |
| TTY Forum/98.09.08.06 | Qualcomm CDMA Data Solution | 11 |

## 4. REVIEW & APPROVE AGENDA

Move Agenda topic #14 to precede Agenda topic #9.  Agenda approved.

## 5. REVIEW & APPROVE TTY FORUM – 6  SUMMARY

Recommend a global change to the TTY-6 Summary report to replace all references made to VCO or HCO with VCO/HCO in the report.  Report accepted with change.

## 6. REVIEW CORRESPONDENCE

Andrea Williams, CTIA, discussed the correspondence (Contribution #5), which she wrote on behalf of the members of CTIA, to comment on the consumer criteria document presented in Forum 6.  The letter addresses the issue that the assembled members from the wireless industry are not able to bind their companies to many of the consumer requirements identified in the document Consumer Requirements for acceptance of One phone model per technology. Many of the issues deal with Section 255 issues.  Andrea asked if the drafters of the letter would meet with Andrea as the CTIA representative.  She and Karen Pelz-Straus, NAD, stated that the document One Phone per Technology agreement is moot as of October 1, 1998.  Andrea and the CTIA Ad Hoc work

group will present their Workplan of scheduled milestones (to be included in the extension request to the FCC) to the TTY Forum.

Comments: Billy Ragsdale: I am confused as to goals. I see this time as where the rubber meets the road. Three months will not gain us anything in getting a digital solution. We need to wait to hear Josh Lober's test results to see what has been accomplished with digital testing before we know where we stand.

Andrea: We need to meet with the representatives and determine the workplan.

Judy Harkins: If we are abandoning the One Phone Consumer requirements then I don't want this document to be used as long-term requirements.

Andrea: Are you saying that the document is no longer to be used?

Judy: The opposite – if the digital models are ready in three months then that's OK, if longer, then the document no longer holds.

Motorola: I don't understand what requirement we seek?

Andrea: We seek the date extension to first quarter 1999.


## 7. TTY LIAISON REPORTS UPDATES: *FCC; CTIA; NAD; TDI*

No reports were made at this time.


## 8. REVIEW / MODIFY / AMEND TTY FORUM *AGREEMENTS*

Change in agreement 6.1 : add "Consumer" to Notification Process. Add "be" to may not "be" supportable in agreement 6.3. Agreements 5.1, 5.2, 5.3 accepted as written.


## 9. ANALOG PHONE AND DEVICE LIST

Lober & Walsh included an updated list of compatible phones in their contributions.

# 10. RANGE STAR PRESENTATION

***Bill Luxon, Greg Johnson, Range Star***

RangeStar has been developing antennas for many years designed to make radios operate better. Located in Silicon Valley, they received additional funding last year which accelerated their pace.

Significant improvements made to improve gains and range with antennas. Come forward to offer full cooperation, use of their lab and drive testing capabilities. Antennas are entirely new design and have received patents. Do not intend to try to gain any price penalty and will supply to manufacturers at prices equal to what they are paying currently.

New antenna use with hearing aid improved performance 95%. Will be tested with cellular phones and is to be given to consumer when they purchase hearing aid. These antennas reduce bit error rates. Wireless carrier tested on a CDMA phone and reduced bit error rates by 60% and reduced draw down on battery by 80%.

Wireless phone's performance is directly affected by the antenna. New findings by Radio Star designed an antenna that has a "C" pattern around the cellular phone. Reduces bit error rate by reducing multi-path error. C-pattern antennas have a gain of 3db (100%) over traditional antennas. Essentially this doubles the power in the system. Reduction in error is seen from both increase in power of signal and reduction of multipath error.

Radiation from the handset reduced SAR test results to 86% from a previously tested 98%. Th C-pattern antenna reduces radiation around the head, and signals aren't blocked by the head.

A phantom for use with tests that duplicates the actual performance as used by humans. Track tests were performed with a cell phone attached to a dashboard

to better simulate performance of a phone with TTY. All C-pattern antennas are for portable applications. They can be attached or built-in.

## 11. WORKING GROUP REPORTS

### WK GROUP # 3: TTY VIA VOCODER AND COUPLING

***Nikolai Leung, Qualcomm***, presented white paper, Contribution #6, to propose using data bits not voice to allow use of error correction. This error correction is transparent to the TTY user. One of the mandates is to be able to call a PSAP – so how do you get the data bits to a conventional user. Use a modem pool between wireless system and the PSTN. Illustration on page 2 of the contribution shows diagram of the model. The converter box (modem pool) converts the data bits back to conventional TTY tones for delivery to the TTY user or PSAP. Existing IS-707 standard for CDMA data services will support TTY and any other V.18 modem. Manufacturers are building to this standard. These provide reliable signals for TTY.

Discussion:

Will the standard cover the user receiving a TTY call. Answer: Yes, the standard covers calling both directions.

Does the standard cover having a blinking light to show a call? No.

The facilities are there in the standards for a pin-out to be activated as a lead. IS-707 has specific commands that are declared as optional to select specific TTYs.

V.18 hardware exists and it is a matter of installing the software as demand builds.

Basic data services means a phone with a digital interface. In the future there may be phones with digital and analog interface.

What will be available by October? When the IWF functionality is available then the functionality in the handset will be usable. You would need BAUDOT in the network to support a conventional TTY device and conventional PSAP.

Major issue is how the TTY would interface – there aren't many that are available today that have the 232 interface.

Voice channel will keep the same underlying error rate but the data channels will be improving so keeping consumers in the analog system will force them to use a system that has higher error rate in the future.

Qualcomm has some data phones that will be coming out in the next month.

This can be considered a hybrid solution – data over the air interface and then converting it back to analog. The long-term solution direction of the Forum is digital over the air interface. This is the long term solution – to support existing TTYs there must be analog – digital – analog conversion.
Most modems are going to wait for the other end to answer before sending information. This can be a problem because the user has to be able to press the space bar before the modem answers.

Sometimes it is necessary to push the space bar to alert the PSAP to the TTY call. If the modem has to connect to the PSAP first, then the caller cannot signal that it's a TTY call by using a space bar. Answer: This can be done – there is no need for the PSAP to answer before the TTY users begin to send their information.
TO support the Qualcomm solution, the modem is already connected before the call reaches the PSAP and therefore, the timing of modems synching up is not an issue. The calls that are V.18 send a signal to identify, the Qualcomm solution will send tones without going through V.18 and there will be no issue with signaling the PSAP.

**Philips Contributions #8, 9:**
Both contributions were presented at TR45.5. Contribution #8 discusses a new service option using the EVRC vocoder to support simultaneous voice and dedicated user data. This contribution does not represent a near term solution but a middle- long term solution in the network

Contribution #9 proposes a methodology that can provide nearly error free transmission of TTY FSK Baudot text over CDMA. This technology can be implemented without any standards efforts. This would make this a short-term solution for CDMA. By providing an interface between the cellular handset and a TTY terminal the errors introduced by the vocoder itself will be eliminated. The solution will require changes in the handset and the network. A diagram of the proposed solution on page 6 of contribution #9 describes the model. Using this model would lead to a probability of bringing error rate down to 1.25-2.5%. If most of the bad frames are isolated the character error would be much smaller and would fall within the 0.5-1% rate determined to be acceptable to the consumer groups.

Discussion:

How soon could this solution be ready? Answer: I can't give you an answer but Lucent and Bell Atlantic are working on this right now seeking a solution. It could possibly be an all software solution.

To evaluate this proposal will take field testing because one of the assumptions is that frame errors are isolated but if frame erasures come in bunches that will impact the ability to correct. This cannot function in normal voice processing.

Is this theory? Yes, the software needs to be developed.

This proposal has been remanded to one of the TR45.5 workgroups. It is designed to let low speed data through a voice call. Packet data would flow simultaneously to voice.

I can't predict the speed of implementation. It depends on interest.

# THROUGH PUT TESTING

***Josh Lober, Lober & Walsh, presented Contributions #10, 11, 12.***

***Contribution #10*** tested TTY over IS-136 Digital Cellular and attempted to identify causes of errors and remedy the concern that the rates of transmission were being slowed too much and didn't represent actual TTY transmission. A new script was generated to address the concern that the original script had unrealistically high numbers of character errors. New script has maximum of 8 character errors per missed shift. The NXI Communications 300VI modem and UltraTec Intele-Modem were tested. Dynamic range is not as big an issue as previously thought.

Results are less than 1% character error rate with level matching, dynamic range matching, and consideration of the different algorithms in different products.

A number of phone manufacturers have different algorithms that affect the way the tones are passed and they are passed differently through different phones.

Standardization is important in the TTY devices to ensure that tones are passed effectively. There is no accepted TTY standard for TTY manufacturers.
If you carefully connect a TTY device to a cellular phone, you get pretty good transmission. Therefore, there needs to be a list of phones that work and TTY devices that work and which work with each other.

Discussion:
If you were going to start with PSAPs to achieve acceptable character error rates, the only way to do it is to make a change in all TTYs. If you make the TTYs slower (to test at ½ rate to improve the error rate), what is the full rate test result? The error rate of 2.84% would be the best you could get at full rate.

This would require a retrofit of all wireline TTYs and PSAPs to achieve half rate results.

TTY has got to move forward – it is locked in 1960s when the networks were very different.

Slowing the TTY transmissions down to half rate is unacceptable because it is slowing down the transmission of the 9-1-1 message.

The slowing down of TTY doesn't require half rate but rather 68 wpm down to 62wpm.

Perhaps we don't have a short-term solution. There may be changes that have to be made to the network, phones, PSAPs.
Lober & Walsh will introduce a reduction in speed to their wireless TTYs. The interface box presented at the last meeting is designed as an inexpensive fix to solve for the return signal.

**Contribution #11**: This test uses three TTY devices and the Motorola i600 iDEN phone. In all cases the iDEN phone was connected directly to a CPT Mobility TTY in the field. The phones were stationary – no drive tests were preformed due to short time available for testing. IDEN phone had a smaller range of tolerance for audio level. There is a line level issue with the UltraTec and NXI in the iDEN environment. Both TTYs performed better in an IS-136 environment.

The iDEN performance was far better than expected through the vocoder. Level matching and dynamic range are key issues.

Discussion:

1.0 Stop bit - do any of the TTY manufacturers have a comment? Answer: The TTYs have worked very well in a POTS environment for 30 years. We'll have to be very careful what we change.

We need to be very careful about making changes to go to half rate because this could become the rate for the long term solution and we also have to pay more to use the phone for the increased air time.

Answer: The long term solution is to move into the PDA (personal digital applicator) rather than going to slower rate Baudot. The long term solution is being addressed and TTY Forum will not close it's doors until the long term solution is in place. The short term solution is seeing testing at an accelerated rate now. The solution from an engineering standpoint is being worked on and the manufacturers and carriers hear the consumer concerns.

There needs to be an auto switch between the speeds to make the TTY device usable.

## 12. STANDARDIZED TESTING AND FINAL EVALUATION

*Josh Lober, Lober & Walsh presented Contribution #12.* The majority of field tests can be done in a lab simulating field results. The purpose of the document is to develop a test that will work for the various air interfaces. It is intended to produce an even playing field. If performance cannot be achieved in the lab, it should not go to the field. The accepted standard is that one phone per air interface technology will perform as well as TTY over analog.

Discussion:
Comment: There have been no tests done on CDMA and there is no technical reason why the intercharacter delay would improve CDMA performance. Therefore, having a time delay will not be beneficial for CDMA.
Answer: It would be interesting to see the results of full rate and slowed rate for all air interfaces.

Attention needs to be put to matching the equipment before testing. NXI mode is specified for all land side testing because NXI is a reliable modem and has agree to alter their software to add delays when specified.

Are there any issues in the PSTN that would affect TTY performance? Answer: Yes there are and we'll see it.

The problem with the non-standardized nature of TTYs goes back to 1988 when the standards body dropped the effort for standards when they could not get the participation of TTY manufacturers. There is no standardization among any TTYs currently. A spec must be developed.

There are standards for the PSTN side.

The mobile manufacturers need participate fully and provide information and user instructions.

Each manufacturer should test their own equipment and will have to develop, purchase, or acquire a scoring application to properly score the tests.

Part 68 of the FCC Order controls transmit levels, receive levels are determined by the manufacturer and the modem international standards should apply.

Effects of hand-offs are not collected in the test. Therefore I'm a little confused about what the spec is going after. Answer: We want to use analog as a baseline. All the digital technologies know basically why TTY doesn't work. Therefore run the objective tests on analog and use that as a baseline. See where the technology stands and determine the root causes and find an answer. Personal opinion is that digital will not meet the performance of analog.

Presented a new test script at the beginning of August to correct for over-calculation of shift errors. The currently accepted test script is in the appendix. The modified script is not currently the accepted script. The TTY Forum needs to discuss whether to accept the test script submitted by Lober & Walsh.

Josh Lober offered to work with the TTY manufacturers to finalize script. A test is available that introduces time delay issues but they are only one factor.

Proposed that full rate only be sent from the land side of TTY and that the speed (full rate, reduced rate) be listed in the test results. The landline side cannot be presumed to be retrofitted in order to solve for digital wireless.

Question to be raised – which manufacturer's phone will become the premier phone to be the standard for TTY to interface with.

Recommend using ¾ rate for lab test simulating the field, then use full rate in the field.

## HCO/VCO

***Contribution #7, Peter Lee from Ameriphone*** presented a letter discussing implications of the built in microphone and receiver on the handset for HCO/VCO applications. They propose a selectively enable headset and microphone for TTY and HCO/VCO use. It also can be used in troubleshooting a bad connection between the handset and TTY.

David Baquis, SHHH, has attempted to gather statistics on VCO/HCO but found the task daunting and was afraid to underestimate the actual population. David needs funding to get a good study of the VCO/HCO population.

## TEST METHODOLOGY

Co-chair, Ed Hall, opened discussion by saying that the initial effort of the TTY Forum was not to produce test results, but having moved to the point where the testing is critical to gathering information, the chair supports a standardized test.

Discussion:

Dick Brandt, Gallaudet and TR30.3, offered to assist by offering expertise gained in TR30.3 testing of modems and to show a test script used in the TR30 testing. He supports the test illustrated in contribution #12. The test must be standardized to produce comparable results.

Ask phone manufacturers to offer one phone that they see as their best offering to compatibility with TTY, then the testing can be run using the most common TTYs from the multiple manufacturers on the market and see if, using a standardized test, they can carry TTY signals adequately.

Need to identify all the elements required and who will do the testing. Does the test certify product or technology? All products in the future may not satisfy the immediate requirements set in the testing today. The CDG intends to test their equipment independently and ensure that they comply with the requirement to support TTY. CDMA cannot support the short-term goal of TTY transmission with errors of less than 1%. CDG is a group of CDMA carriers and manufacturers dedicated to building consensus and standards within the industry. The CDG has its own test team for TTY and has worked on these issues with CTIA. Meetings are held every week, good representation from six or seven carriers and manufacturers. Contribution #14 represents the opinion of the members present at the last TTY meeting of the CDG.

Ericsson has seen the process used by the CDG and accepts the belief by the CDG that there is no short term solution but that they should work on the long term solution. The TDMA and GSM groups do have data that is hopeful that

there will be a short-term solution and that Ericsson, as a manufacturer, can build products to support the demands. How do the consumer groups feel about the position of the CDG?

Consumer groups see this as a carrier responsibility so each carrier will have to address this. Consumer groups would like to see testing and every effort to speed the long term solution. If there is no way to provide a technically feasible short term solution then there is not much the consumers can say about that. On the surface, we have no problem with the CDG saying "we can't do it" but expect to see the carriers deal with the issues.

The User Acceptability Test would give us an end result of how the user uses the product and if it's acceptable. The TTY Forum should get that test back on track. The work that must be done has to be checked off by this Forum so the testing that's done independently cannot be quantified unless we have some standardized measure that this Forum can understand and quantify. Therefore, we need to get back to what the baseline tests need to be and how they are to be done. If the CDMA short term solution cannot be achieved then they should be exempted from the short term solution. The other two digital technologies have shown promise of finding a solution and should complete the testing to provide a feasible short term solution. The TTY Forum should remain operational until solutions are provided and accepted for all digital technologies.

The baseline is that the digital solution must meet analog performance before the solution is acceptable.

The CDG indicated that there are alternatives to the two proposed solutions: going thorugh the vocoder or going around the vocoder. The Hybrid is to modify the vocoder. It is not a short term solution because it requires a infrastructure change and standards work. It is theoretical but has not been ruled out. This would be an analog solution so the value would have to be weighed.

The Steering committee expressed disappointment with the length of time that it took for the CDG to come forward and say that it cannot be done. There is agreement that if it cannot be done we should not waste time and say so and move forward.

The statements made yesterday that the solution must meet a 1% or less error rate may exclude all digital interfaces from a short term solution. IDEN will have a hard time getting down below 4% error rate.

Co-chair stated that there has been no final number established for error rate. If due diligence is performed and the numbers presented as the best results that the industry can prove and it is X% then the results must be presented to the TTY Forum. If they are not acceptable to the Forum, then the net step is to go to the FCC.

The consumer groups feel that we need to go forward with the process. We have spent a lot of time on consensus building. But the consumers are not getting anything from this. We need a working plan to provide a short term goal and long term goal. The consumer is losing out – we are waiting for a solution and it's not there.

Co-chair asks if the test plan will go forward. Carriers support the test plan. TTY manufacturer supports the test plan if it is to test the technology not UltraTec's products.

Comment on the character error rate: I have no concept of what is acceptable to the consumer in reality. I have never seen a test pattern or any data that shows what is acceptable to TTY users. The equipment that provides tested error rate should be identified in fairness to the consumer. It has been identified in the testing reports submitted to this Forum that there are differences in compatibility

and tolerances between TTYs. The TTY manufacturers need to come to the table to help with the interface problems. This does not state that the TTY manufacturers have a bad product but rather that there are issues that need to be resolved technically.

Since 3$^{rd}$ generation and even 4$^{th}$ generation issues are being addressed in standards currently that will impact the future of all wireless communications. If there is no cooperation from the TTY manufacturers this group will be faced with the same problems in a few years.

Proposal to accept Contribution #12 as a working document to represent the basis of the test plan.

Josh Lober led the modification of the contribution on-line.
Discussion: Are provisions for CDMA to be included in the working document.

Draft of the Proposed work plan from CTIA to be presented to the FCC with a request for extension.:
Offers a test suite appropriate to each technology. Ericsson recommends that the working document be submitted to each technology working group as a guideline to allow for common benchmarking and to produce the proper work plan for their technology.

Accountability is a key to identifying whether the test plan will be completed and testing performed. The manufacturers and technology working groups do not have specific accountability for any action. The carriers hold the accountability. The TTY Forum is the accountable organization.

The Technology working groups are formed by carriers and manufacturers so they are accountable. The carriers do not necessarily agree that the accountability is clearly with the technology working groups.

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Document should be modified globally by identifying concerns with areas of the testing. Work of this committee could be extended by including the technical working groups.

To move forward, use the general terms that the TTYs will be tested in a strong, medium and weak signal environment. Various other details should be optional or equivalent as they pertain to the air interface technology.

Send the globally modified working document shall be sent to the technology working groups to modify for their technology. Carriers request that the document be sent directly to the phone manufacturers as well as the working groups.

Will VCO/HCO be specifically called out in the test plan to provide for transmission? The performance tests of the final solution will test for voice transmission and VCO/HCO issues. VCO/HCO will be tested after the TTY transmission is proven.

A working group was formed to decide whether the introduction of intercharacter delays on both ends of the TTY transmission would be accepted and to finish the agreement on the test plan document. Group members:
Brad Blanken
Nikolai Leung
Judy Harkins
Josh Lober
Paul Skollar
Ron Schultz
Steve Costen
Billy Ragsdale

Request for TTY manufacturers volunteer equipment for the test. The Ultratec Intelemodem will be used for the landline side of the testing. The baseline will be established for analog then testing will begin with digital.

## END USER BENCHMARKING

Judy Harkins presented an end user script that represents two way communications with errors introduced. The script is then simulated through software developed at Galluadet that can introduce specified percentage of errors.

# 13. FCC EXTENSION REQUEST PROCESS

CTIA plans to request a three month extension of the FCC Wireless Bureau as of this Friday. To get a longer extension a request must be submitted to the FCC in full. A work plan will be submitted with scheduled milestones. The FCC will see the effort made. They can put the request out for comment.

Comment from consumers: You should put the request in CTIA's name since it will not reflect the consensus of the stakeholders. Answer: That would be fine.

Question: What are the milestones that will be included? Answer: The milestones will reflect starting dates for work on issues as gathered from Andrea's discussions with manufacturers, carriers, as realistic and achievable deliverables.

Continued discussion, Day 2:
The Proposed Workplan was distributed as Contribution #16. It was presented as a document prepared by CTIA and not as a representative document of the TTY Forum. Confusion was expressed regarding the separation of the effort from the TTY Forum. The manufacturers and consumer groups expressed that the document should come from the TTY Forum. The consumer groups stated that they take issue with the sentence saying that the other stakeholders must

work cooperatively with the wireless industry. The sentence makes it look like the stakeholders have not been working with the industry. Consumer groups think that the TTY Forum represents cooperation among all the stakeholders. The sentence should read that the wireless industry must work cooperatively with the stakeholders.

The consumer groups stated that the members of the TTY Forum do not understand why there is a separate Ad Hoc group. A manufacturer member of the Ad Hoc group expressed discomfort with the process and the contents of the document. Andrea Williams stated that the document will be filed and will state that it represents the views of discussions with CTIA members but not the TTY Forum. The FCC can interpret the document as initial input from the industry. Then the document can be discussed.

Chair recommended that the TTY Forum submit a simple letter to the FCC stating that the Forum has submitted quarterly reports, has shown due diligence, and requests a three month extension.

Carriers supported that effort and stated that the TTY Forum needs to communicate directly with the FCC or the TTY Forum will be derelict in their duties. Consumer representatives stated that the Forum must remain together as a group of stakeholders. CTIA will provoke separate comments if they insist on submitting as an individual group. The consumer groups remind the Forum what happened with the hearing aid issue where the stakeholder agreements fell apart when one group went off on its own to communicate with the FCC. The consumer groups stated that they are now considering providing their own filing to the FCC if CTIA follows an independent course.

There is a subset of the Ad Hoc group made up of manufacturers that has built the Workplan (contribution #16). The Workplan is to be submitted with the request for an extension. The Workplan is to be presented to the TTY Forum.

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The Chair agrees to prepare the letter to the FCC and put it out on the listserver to get the TTY Forum's agreement. When agreement from the stakeholders is achieved then it will be submitted to the FCC.

## 14. CONSUMER REQUIREMENTS DOCUMENT

*Judy Harkins, Gallaudet University, presented Contribution #15.* Judy Harkins Document applies to all models of phones since CTIA declared "one phone per technology" moot. The document focuses on design and technology rather than the marketing and distribution. Andrea Williams, CTIA, clarified that her letter did not mean to say that the "one phone per technology" issue is moot, just that the ability to deliver one phone per technology by October 1, 1998 is moot.

Revision to contribution #15 to read: (Item) 4. The caller must be able to transmit TTY tones independent of the condition of the receiving modem.

The wireless phone should be made hearing aid compatible.

## 15. NEW BUSINESS/NEXT STEPS.

The proposed extension letter will be sent to the TTY Forum via the list server for approval. Brad Blanken will chair a working group to finalize verbiage in the standardized test plan an distribute to all technology working groups and phone manufacturers.

## 16. NEXT MEETING

Next meeting are scheduled for:

October 7 & 8 – Washington, DC

November 4 & 5 – Baltimore, MD

## 17. ADJOURNMENT

The co-chair, Ed Hall, adjourned the meeting.

# ATTENDANCE

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| Kelly-Frey, Brenda | State of MD MD Relay | 410-767-5891 | | frey@dbm.state.md.us |
| Kelley, Scott | Motorola | 847-523-5210 | 847-523-8274 | Scott_kelley@css.mot.com |
| Lantor, Todd | PCIA | 703-939-0300 | 703-836-1608 | lantort@pcia.com |
| Lee, Peter | AmeriPhone | 714-897-0808 | 714-897-4707 | Peterl@ameriphone.com |
| Leung, Nikolai | Qualcomm Inc. | 202-530-3927 | 202-833-2161 | Nleung@qualcomm.com |
| Lober, Joshua | Lober & Walsh | 805-544-1089 | 805-544-2055 | Josh@lweinc.com |
| Luxon, Bill | Range Star | 888-647-7100 | 888-647-7101 | |
| Moller, Paul | Motorola | 847-523-5210 | 847-523-8872 | paul-moller@css.mot.com |
| Montgomery, Bob | Nextel | 703-394-3590 | 703-394-3750 | Bob.montgomery@nextel.com |
| Olson, John | PCC | 732-878-8374 | 732-463-6868 | Jolson@pcc.lucent.com |
| Parker, Virginia | Qualcomm Inc. | 619-658-4789 | 619-651-8962 | vparker@qualcomm.com |
| Peltz-Strauss, Karen | NAD | 301-587-7466 | 301-587-1234 | kpstrauss@aol.com |

| | | | | |
|---|---|---|---|---|
| Ragsdale, Billy | NENA/BellSouth | 404-329-4146 | 404-325-2798 | Bragsdal@bellsouth.net |
| Schultz, Ron | Ultratec | 608-238-5400 | 608-238-3008 | Rschultz@ultratec.com |
| Sonnenstrahl, Al | CAN | 301-770-7555 (TTY) | same | sonny@clark.net |
| Spencer, John | FCC | 202-418-1896 | | Jspencer@fcc.gov |
| Stout, Claude L. | Telec. for the Deaf, Inc. | 301-589-3786 (V) | 301-589-3797 | tdiexdir@aol.com |
| Thomas, Al | Bellsouth Cellular | 404-713-0361 | 404-713-0361 | Al.thomas@bscc.bls.com |
| Uzuanis, Richard | HITEC | 630-654-9200 | 630-654-9219 | Richard@hitec.com |
| Whritenour, Lee | Bell Atlantic Mobile | 908-306-6485 | 908-306-6489 | lwhrite1@mobile.bam.com |
| Williams, Andrea | CTIA | 202-736-3215 | 202-785-8203 | awilliams@ctia.org |
| Wlliams, Norman | Gallaudet University | 202-651-5257 | 202-651-5476 | nswilliams@gallaudet.edu |
| Wood, Chuck | U.S. Cellular | 773-399-7090 | 773-399-4984 | Cwood@cellular.uscc.com |

# APPENDIX A

## AGREEMENTS FROM TTY FORUM – 7

**7.1** The TTY Forum should remain operational until solutions are provided and accepted for all digital technologies.

**7.2** The baseline for the digital solution is wireless analog performance.

**7.3** Accept Contribution #12 as a working document to represent the basis of the test plan. Test Plan as modified by the technology groups (CDG,UWCC,GSMNA) will be sent to all phone manufacturers. Test plan will measure the performance of various digital air interface technologies.

**7.4** Where possible, VCO/HCO should be included in the testing, design, and availability of TTYs, cellular phones, and air interface technologies.

**7.5** The TTY Forum will submit a request for a three month extension to the FCC.

## AGREEMENTS REACHED AT TTY FORUM - 6

**6.1** Any carrier not in compliance with the Consumer Notification Process established at TTY Forum should be brought to the attention of the TTY Forum for resolution.

**6.2** Working Group #1 is officially dissolved having completed its initial charter. Any further testing results would be forwarded directly to the TTY Forum.

**6.3** A lack of TTY technical standard has resulted in a variance of TTY performance levels manifested when used on digital networks. As such, in developing the "short-term" digital solution, certain least used models of TTY may not be supportable on all digital air interfaces.

## AGREEMENTS REACHED AT TTY FORUM - 5

**5.1** As an initial step, carriers who can offer TTY users at least one digital phone model for each digital technology that a carrier offers at a reasonable price by October 1, 1998 would be considered in compliance of the E9-1-1/TTY compatibility requirements.

**5.2** The FCC can use the information contained in the notification letter in any way they feel would expedite getting the information to the consumer.

**5.3** All test results submitted will be included in the next Quarterly Status Report.

## AGREEMENTS REACHED AT TTY FORUM - 4

**4.1** Objective test (Throughput Test) approved and to be sent to manufacturers and carriers with a matrix to record testing completion dates and documentation.

**4.2** TTY Forum Test Completion Matrix approved.

**4.3** Consensus reached that Testing Matrix should go to every manufacturer listed at CTIA as well as Wireless and Wireline Carriers. CTIA/PCIA will escalate/elevate TTY Forum efforts to reach wireless equipment manufacturers and inform of urgency and criticality of rapid response to the Testing Matrix via a letter from the TTY Forum and CTIA/PCIA.

The group recognizes that participation is voluntary. Copies of letter and matrix responses will be sent to the FCC.

**4.4** RFI will be put on issues list to explore possibility of interference between phone and TTY device.

**4.5** Consensus to put TTY Forum's current research opinion on output voltages (coupling information) into a formal document and present to manufacturers for feedback. Give 30 days for feedback.

**4.6** Subjective test (End User Test) to be finalized by committee. Testing will be handled through Gallaudet with assistance from Wireless manufacturers and TTY manufacturers. Will replicate authentic 9-1-1 calls with a deaf/hearing impaired caller and a trained calltaker.

**4.7** CTIA will produce a list of Analog Phones that are compatible with TTY devices to be included in notification efforts and on web sites due as a Contribution at the next TTY Forum.

**4.8** Gallaudet University and Consumer groups will draft a Consumer Requirements Document due as a Contribution at the next TTY Forum.

**4.9** CTIA/PCIA will send letter to wireless equipment manufacturers requesting that they support Gallaudet University in their testing efforts by sending equipment.

**4.10** Standards Requirements Documents (SRD) due for V.18 and the 2.5 mm jack as Contributions at next TTY Forum.

## AGREEMENTS REACHED AT TTY FORUM - 3

**3.1** 6 sponsored spots for identified consumer groups, relinquished if member misses 2 consecutive meetings.

**3.2** Accept modified "readability test" to be used by phone manufacturers to benchmark TTY over digital capabilities, to determine success rate for transport. (See Contribution TTY/98.02.11.06) Two tests: Manufacturers Readability Test, End User Test

**3.3** Error rate is defined as "character" not "bit" for the purpose of this forum. (Shift error rate of ratio 1/8 (i.e. 1 shift error causes up to eight text errors and will be counted as such) to be determined)

**3.4** Develop User Requirements Document. The outcome of Working Group #2. Represents the effort to provide for future advancements in technology by looking at solutions beyond 45.45 baud, Baudot.

**3.5** Define process to update Notification Document: refer updated information to CTIA to be distributed to T-CAT.

## AGREEMENTS REACHED AT TTY FORUM - 2

**2.1** Combine Working Group #1 and Working Group #3. Develop new set of deliverables based on the October 1, 1998 deadline.
- Short term solution: solve for backward compatibility.
- Develop Standard Test to measure error rate of TTY over digital.

## AGREEMENTS REACHED AT TTY FORUM - 1

**1.1** "Solve for 45.45 Baudot, not to preclude looking for other solutions."

- Look for long term and near term solutions.
  - <u>Near term</u> - send through vocoder
  - <u>Long term</u> - circumvent vocoder, enhance quality and connectivity
- Provide for the analog function of wireless phones.
- The only body that can change the agreements reached is this body. All agreements remain intact until/unless action is taken in this forum.

# APPENDIX B

## Recommended Text
## Consumer Notification

ATTENTION TTY USERS

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Background

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*A TTY (also known as a TDD or Text Telephone) is a telecommunications device that allows people who are deaf, hard of hearing, or have speech or language disabilities to communicate by telephone. A TTY has a keyboard used to type a conversation, which then is transmitted as tones over a wired telephone line. The tones are translated to text that appears on a person's TTY screen.*

## 911 and TTY Access Through Wireless Services

Federal law requires the telecommunications industry to provide a way for TTYs to communicate through **wireless systems** to make 911 calls. There are two types of wireless phones – analog and digital.

- Analog – It is possible today to use some analog wireless phones reliably to call 911 with a TTY.

- Digital – It is not possible today to use a digital wireless phone reliably to call 911 with a TTY.

Research is being done to improve the ability of digital phones to work reliably with TTYs. The industry is working to resolve this matter by October 1998.

[Optional: For more information, contact . . . ]

DATE OF PUBLICATION:

# APPENDIX C

# TTY Forum Issue Statements

6.1   The TTY Forum doesn't support one solution over the other but it seems that the
2.5 mm jack is preferred

6.2  It is acceptable in concept to retrofit the TTY at no cost to the user.  Concern
was expressed regarding warranty work, and who would perform work on
equipment.  The retrofit should not eliminate or impact any functionality previously
available to the user. Time to retrofit should be reasonable. A liaison should be
established between manufacturers and user groups to ensure "certain conditions"
are met.

6.3  The issue of the false propagation of errors, created by the incorrect receipt of
a shift character should be addressed through use of an appropriate test script.  The
script should contain multiple shifts space apart so that a realistic distribution of
character errors would result, based on frequent (although not universal) practice of
correcting shift errors by user action.  A normal distribution between 1 and ? with a
median of about 8 would be appropriate.

# APPENDIX D

TTY FORUM MANUFACTURER TESTING COMPLETION MATRIX

| Manufacturer | Technology | Through Put Test (Contribution) | Type of Test (Field, Lab) | Contact Name & Number |
|---|---|---|---|---|
| Philips | Analog | 98.07.21.07 | | Ken Wells |
| | | | | |
| Motorola | Analog | 98.05.20.20 | | Paul Mollar |
| Sendele | Analog | 98.07.21.05 | | Steve Sendele |
| | | | | |
| Motorola | CDMA | 98.05.20.20 | | Paul Mollar |
| Lucent | CDMA | 98.05.20.10 | | Ahmed Tauf |
| Nokia | CDMA | 98.05.20.17 | | Mohamed El-Rayes |
| Qualcomm | CDMA | 98.05.20.12 | | Virginia Parker |
| | | | | |
| Ericsson | GSM | 98.02.11.07 | | Christopher Kingdon |
| Nokia | GSM | 98.05.20.17 | | Mohamed El-Rayes |
| Motorola | GSM | 98.05.20.20 | | Paul Mollar |
| | | | | |
| Ericsson | TDMA | 98.02.11.05 | | Christopher Kingdon |
| Motorola | TDMA | 98.05.20.20 | | Paul Mollar |
| Nokia | TDMA | 98.05.20.17 | | Mohammed El-Rayes |
| Philips/CPT | TDMA | 98.07.21.07 | | Jim De Loach 510-445-5510 |
| Lober & Walsh | TDMA | 98.09.08.10 | | Josh Lober |
| CPT | TDMA | 98.07.21.08 | | Josh Lober |
| | | | | |
| Lober & Walsh | iDEN | 98.09.08.11 | | Josh Lober |

# APPENDIX E

# TTY USER REQUIREMENTS

September 10, 1998

To: TTY Forum

Fr: Consumer Representatives

The CTIA has said that most of the consumer criteria previously submitted were not usable by the TTY Forum because the criteria covered marketing and distribution as well as design. Marketing and distribution issues for a possible "one-phone-model-per-technology" short-term plan will be taken up with CTIA's senior management, as suggested by them.

This contribution is a new set of criteria to address only functional characteristics of the solutions. The new criteria also reflect new information from the Forum since the first list was drawn up. It is intended to cover any solution.

1. The character error rate should approximate that of AMPS, which has been demonstrated at <1% for stationary calls. More research on AMPS performance with TTY would be useful to assist in specifying a range of conditions.

2. The TTY caller must be able to visually monitor all aspects of call progress provided to voice users. Specifically, the ability to pass through sounds on the line to the TTY (so that the user can monitor ring, busy, answered-in-voice, etc.) should be provided.

3. There must be a visual indication when the call has been disconnected.

4. A volume control should be provided.

5. The TTY user must have a means of tactile (vibrating) ring signal indication.

6. The caller must be able to transmit TTY tones independent of the condition of the receiving modem. (This is to permit baudot signalling by pressing a key, to let a hearing person know that the incoming call is from a TTY.)

7. The *landline* party's TTY must not require retrofitting in order to achieve the desired error rate.

8.  The *wireless* party's TTY may require retrofitting, or a new model TTY to be developed, or the use of a portable data terminal such as a personal digital assistant.

9.  VCO and HCO should be supported where possible.

10. Reduction of throughput (partial rate) on Baudot is highly undesirable and should not be relied upon to achieve compliance (see #7). It may be useful as a user-selectable option to improve accuracy on a given call.

11. Call information such as ANI and ALI, where provided in wireless voice, should also be provided for TTY calls.

12. The solution need not support little-used or obsolete TTY models, but in general should support the embedded base of TTYs sold over the past ten years. The landline equipment supported must not be limited to that used in Public Service Answering Points (911 centers).

13. Drive conditions must be supported, again using AMPS as a benchmark.

# APPENDIX D

# Cellular Product Technologies, LLC

## Test Results
## for
## TTY/TDD
## Over Live Digital Cellular Networks

## July 21, 1998

# Cellular Product Technologies, LLC

- Digital Cellular Network
  - IS-136 Time Division Multiple Access (TDMA)
  - Cellular One of San Luis Obispo (San Luis Obispo Cellular)
  - Roaming on ATT Wireless, site SB11O back-hauled to MTSO in Goleta.
    - Omni-directional Cell
    - Longitude 120° 26' 37" West
    - Latitude 34 ° 56' 36" North
  - Network supports ACELP Vocoder only

- Digital Cellular Phones[1]
  - Philips Consumer Communications - Aeon
  - NEC of America - Digital Talk 2000
  - Motorola - M70A

Notes:
1. It is not the goal of CTP to test the performance of the individual phones, therefore test data will refer to these phones as Phone "A", "B" and "C".

# Cellular Product Technologies, LLC

- **Tests Performed on IS-136 Digital Network**
  - Stationary Test
    - Cellular Phone and TTY inside a parked car.
  - Drive Test[1]
    - Cellular Phone and TTY inside a car, driving on city streets (under 40 MPH).
  - Freeway Test[2]
    - Cellular Phone and TTY inside a car, driving on city streets and Freeway (including TDMA to AMPS handoff) of speeds up to 65 MPH.
  - Script Transmission Rate
    - Full Rate Test
      - 4164 Characters transmitted with no delays between characters
    - Half Rate Test
      - 4164 Characters transmitted with a 167mS delay between characters

Notes:
1. Due to safety concerns, Cellular Product Technologies does not recommend the use of a TTY while driving a motor vehicle.
2. These tests are not included in summary averages, as they were only performed to measure performance in unsuitable operating conditions.

# Cellular Product Technologies, LLC

- TTY Over IS-136 Digital Cellular - Test Platform
  - Transmitting TTY
    - CPT Mobility™ TTY with DVC™ Technology (32K RAM Installed)
  - Receiving TTY
    - CPT Mobility™ TTY with DVC™ Technology (32K RAM Installed)
    - RS-232 Serial Port Installed
  - Software Version 1.4T (includes CTIA recommended test script)
  - Test Script Generation
    - Internal to Mobility™ TTY
  - Test Script Reception
    - P.C. Capture using XTALK via RS-232 Port on Mobility™ TTY
  - Scoring Method
    - SCORE.EXE Application developed by Lober & Walsh Engineering
      - UNIX and WIN32 Versions Available

# Cellular Product Technologies, LLC

## Land to Mobile Configuration



PC captures received TTY characters and scores results

Mobile Switching Center

RS-232 data  Mobility TTY

Public Switched Telephone Network

TTY sends CTIA test script

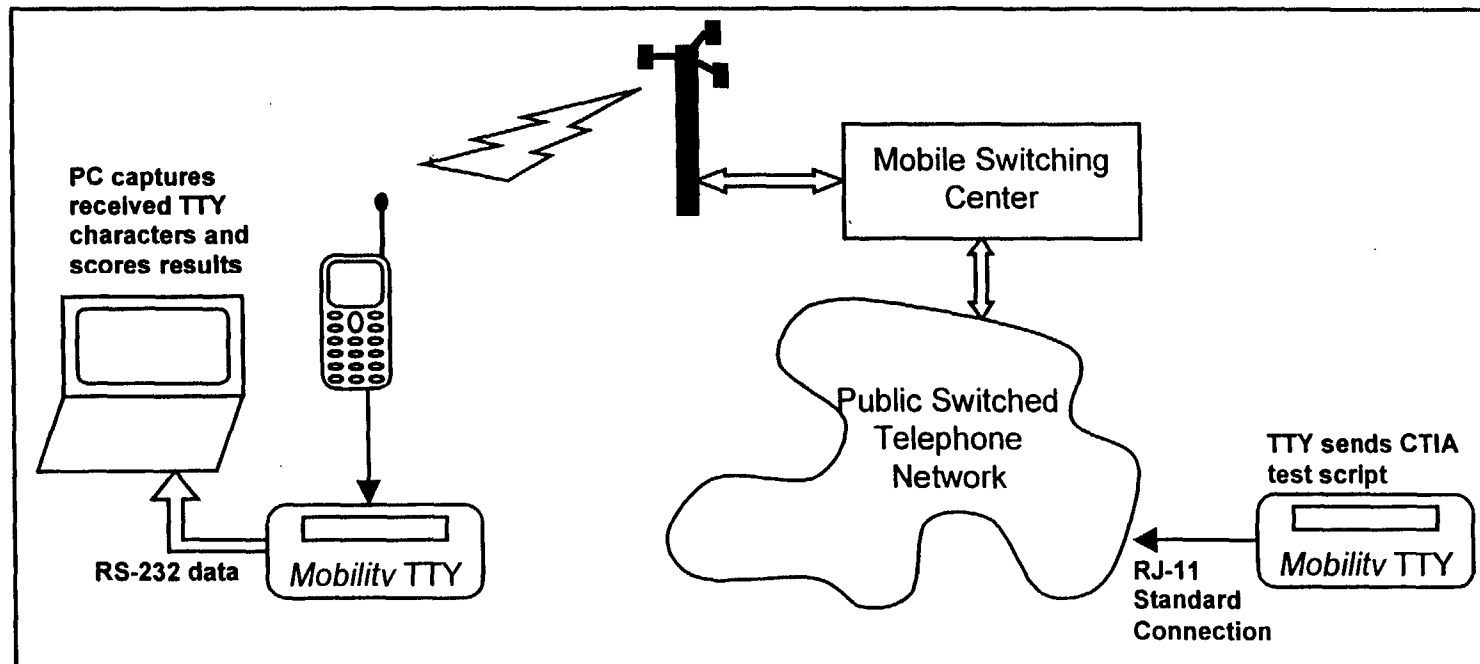RJ-11 Standard Connection  Mobility TTY

Illustration provided by Philips Consumer Communications

# Cellular Product Technologies, LLC

## Mobile to Land Configuration



Illustration provided by Philips Consumer Communications

# Cellular Product Technologies, LLC

## Mobile to Mobile Configuration
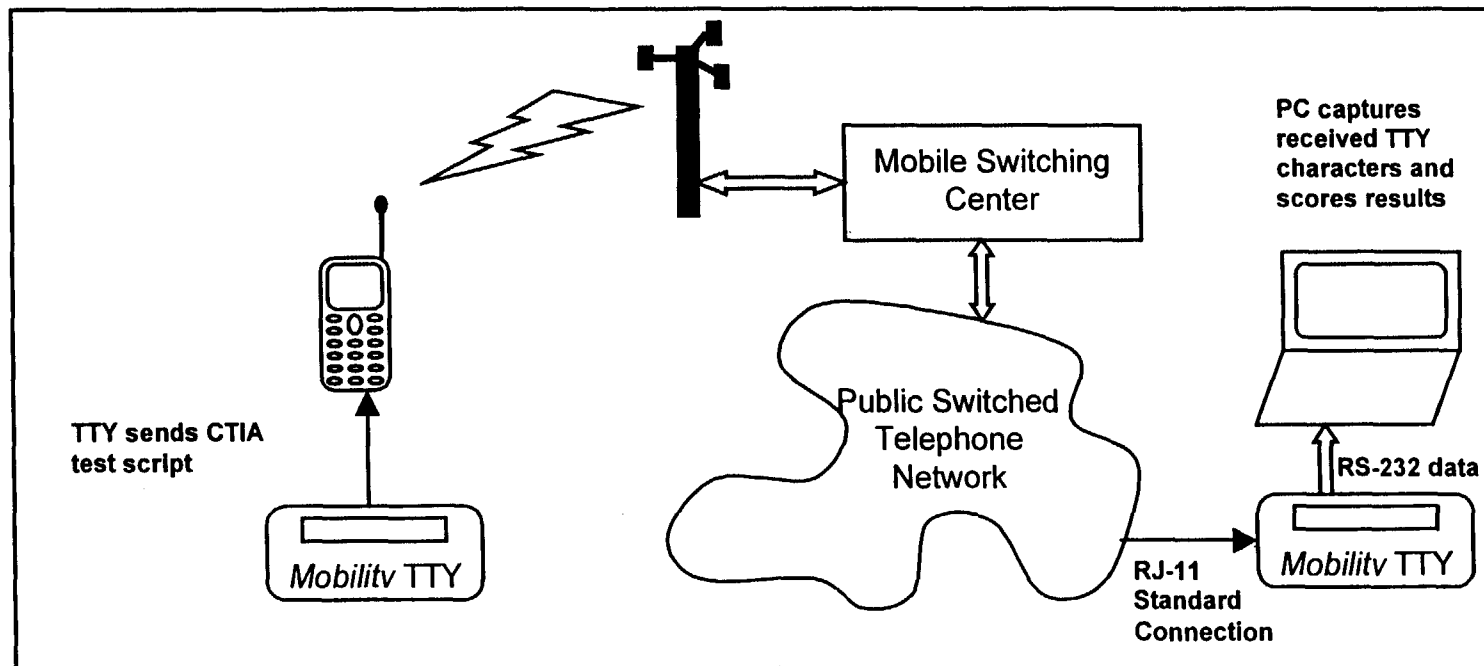
Digital

Analog

Mobile Switching Center

*Mobility* TTY

TTY sends CTIA
test script

PC captures
received TTY
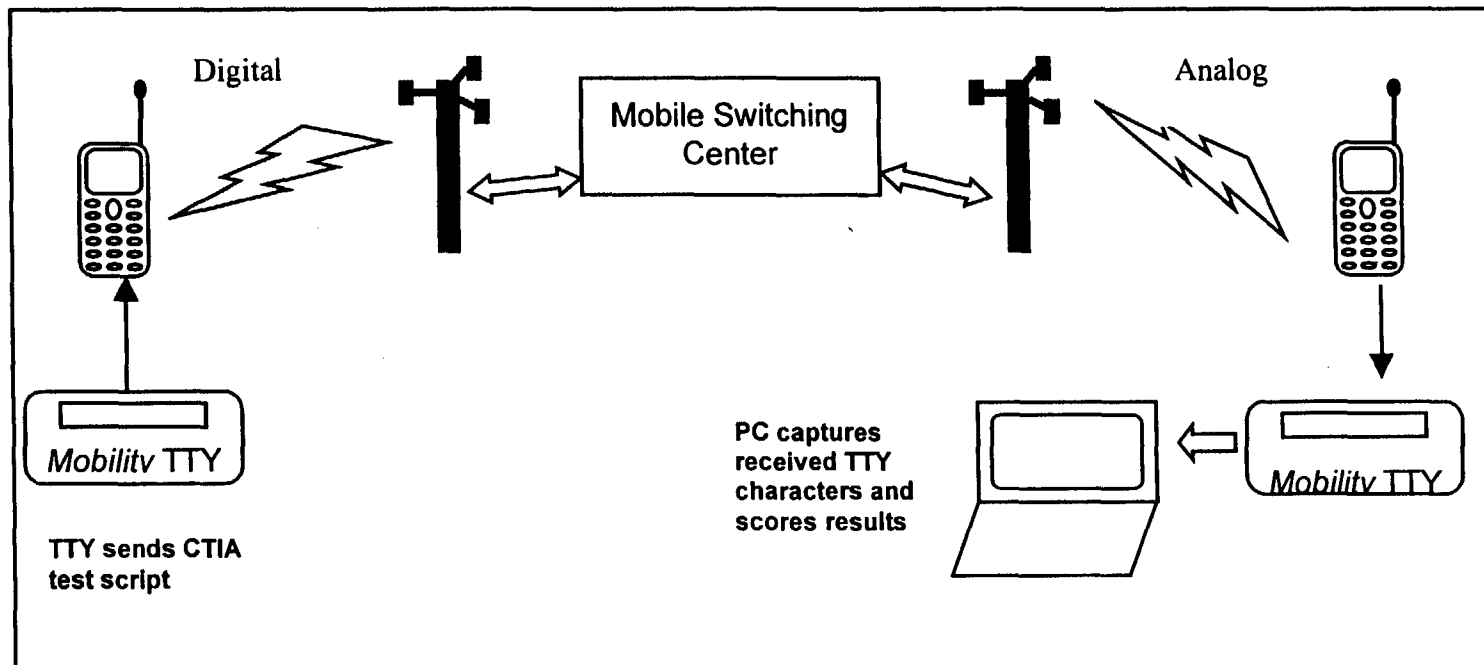characters and
scores results

*Mobility* TTY

Illustration provided by Philips Consumer Communications

# Cellular Product Technologies, LLC

Small Sample Testing
(using Mobility™ TTY as a baseline)



PC captures received TTY characters and scores results

Mobile Switching Center

Public Switched Telephone Network

RJ-11 Standard Connection

Mobility TTY

Mobility TTY

Other TTY

TTY sends CTIA test script
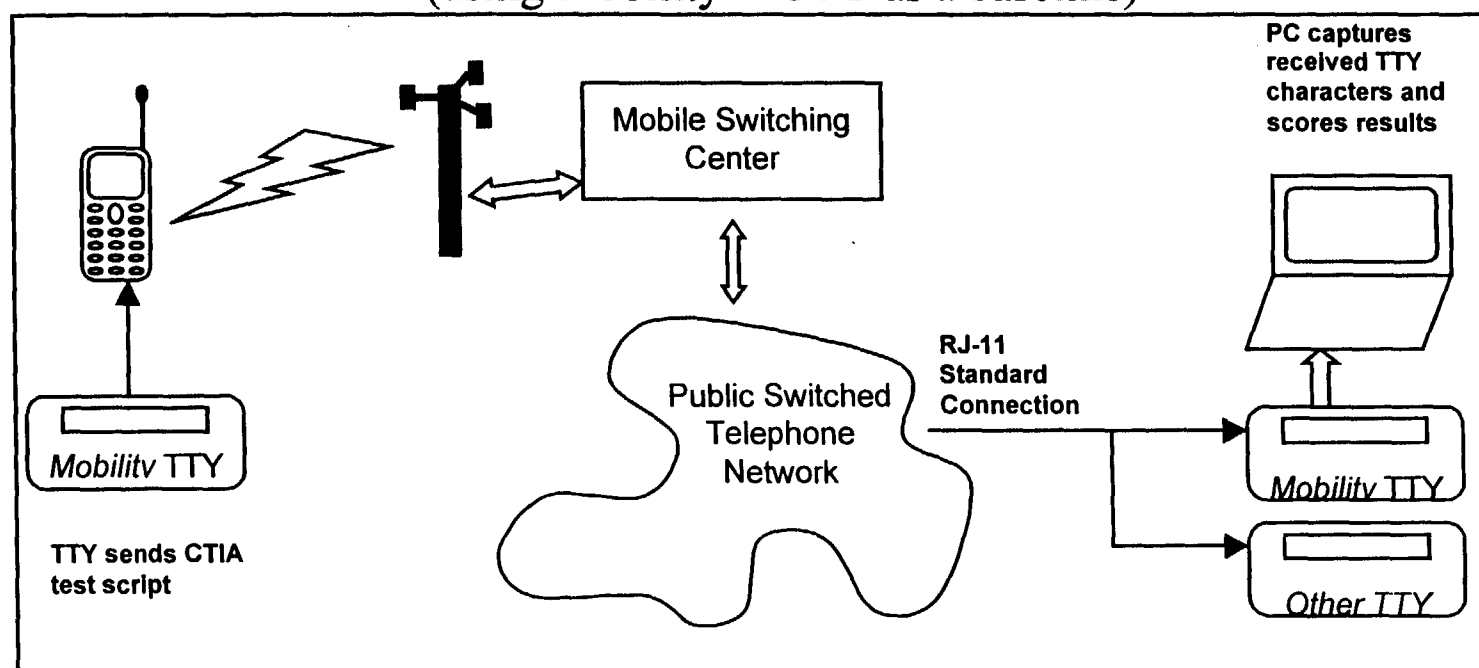
Other TTYs tested are:
1 Ultratec Superprint
2. Ultratec Compact
3. Ultratec EZCom Pro
4. Ameriphone Dialogue IIP

Illustration provided by Philips Consumer Communications

# Cellular Product Technologies, LLC

- **Score Program**
  - SCORE works by finding the best match between a transmitted script file and the received script file.
  - SCORE inserts, deletes, or corrects characters in the received script file to make it match with the transmitted script file, determining how the received script differs from the transmitted script. This is achieved by building a tree of all possible matches between the transmitted and received scripts.
  - Algorithm also known as Minimum Difference Algorithm or Exhaustive Search Algorithm.
  - Characters that were **inserted** are scored as a **missed** character.
  - Characters that were **deleted** are scored as an **added** character.
  - Characters that were **corrected** are scored as a **changed** character.
  - Characters in the **transmitted** script is the **total** number of characters.
  - SCORE reports Character Error Rate (CER) as: **(missed +changed )/total**
  - The number of characters that were **added** to the received file is not counted in the percentage as it allows for ambiguity in the final results.
  - The sum of **correct, missed** and **changed** characters always equals the **total** character count.

# Cellular Product Technologies, LLC

- **Score Example**
  - Transmitted Script: The quick brown fox jumped over the lazy dogs.
  - Received Script: Te ui brow3fox jumped over the lazyFdogs.
  - Score: T#e #ui## brow##fox jumped over the lazy#dogs.
    - Character Error Rate = 14.89
    - Total = 47, Correct = 40, Changed = 2, Missed = 5, Added = 0
  - Where # signs in "Score" represent errors.

- **Ambiguity of Added Characters in Score Results**
  - Transmitted Script: ABCDE
  - Received Script: ACCDE
  - Score: A#CDE
  - Results
    - Score Method 1
      - SCORE **corrected** the "C" in position 2 to a "B".
      - Total = 5, Correct = 4, Changed = 1, Missed = 0, Added = 0
      - CER without **added** = 20%, CER with **added** = 20%
    - Score Method 2
      - SCORE **inserted** a "B" before the "C" in position 2, and the "C" in position 3 was **deleted**.
      - Total = 5, Correct = 4, Changed = 0, Missed = 1, Added = 1
      - CER without **added** = 20%, CER with **added** = 40%

# Cellular Product Technologies, LLC

- IS-136 Conclusions

  - Good results were achieved independent of phone manufacturer.

  - Test results in terms of CER vary depending on the quality of the "land side" and "mobile side" TTY's FSK receiver. Cellular Product Technologies Mobility™ TTYs[1] were used for all "full length" tests.

  - Reliable conversation[2] from a stationary location with good signal strength[3] is achieved on an IS-136 Digital Traffic Channel.

    - **Half Rate - average CER of 0.88%.**

    - **Full Rate - average CER of 2.84%.**

  - Reliable conversation from a moving vehicle[4] with good signal strength is also achieved on an IS-136 Digital Traffic Channel.

    - **Half Rate - average CER of 1.70%.**

    - **Full Rate - average CER of 3.31%.**

  - Introducing inter-character delays reduces character errors:

    - **Stationary Test CER improvement 1.96%**

    - **Drive Test CER improvement 1.61%**

# Cellular Product Technologies, LLC

- **IS-136 Conclusions (continued)**

  - Small sample[5] testing was performed using the following "land side" TTYs. A Mobility™ TTY was used in parallel to baseline the test:

    - **Test 1**
      - Mobility™ TTY:  CER: 01.18%, Total: 510, Correct: 504, Changed: 05, Missed: 01, Added: 00
      - Ultratec Compact[A]:  CER: 18.04%, Total: 510, Correct: 418, Changed: 46, Missed: 46, Added: 05

    - **Test 2**
      - Mobility™ TTY:  CER: 00.39%, Total: 510, Correct: 508, Changed: 02, Missed: 00, Added: 03
      - Ultratec EZCom Pro[B]: CER: 23.14%, Total: 510, Correct: 392, Changed: 55, Missed: 63, Added: 05

    - **Test 3**
      - Mobility™ TTY:  CER: 00.78%, Total: 510, Correct: 506, Changed: 03, Missed: 01, Added: 00
      - Ultratec Superprint[C]:  CER: 08.24%, Total: 510, Correct: 468, Changed: 19, Missed: 23, Added: 00

    - **Test 4**
      - Mobility™ TTY:  CER: 00.00%, Total: 510, Correct: 510, Changed: 00, Missed: 00, Added: 00
      - Ameriphone Dialogue[D]:CER: 02.35%, Total: 510, Correct: 498, Changed: 07, Missed: 05, Added: 01

Notes:
A. Compact has no Serial Number visible, and is an acoustic coupled device.
B. EZCom Pro Serial Number 7310002270 is a direct connect device.
C. Superprint 4420 Serial Number 58636 was used in direct connect configuration.
D. Dualogue IIP Serial Number 17127 was used in direct connect configuration.

# Cellular Product Technologies, LLC

- **◦** IS-136 Conclusions (continued)

  - – FACCH[6] messages result as additional character errors.

  - – High Character Error Rates result from "low quality" cellular connection.

  - – **Because of the variance in quality of TTYs in the field today, it is not possible to ensure acceptable Character Error Rates without replacing or "enhancing" the existing TTYs. CPT is currently designing a "retrofit module", designed to give existing TTYs the same performance as the Mobility™ TTY.**

Notes:
1. The Mobility™ TTY FSK receiver has a dynamic range greater than 49dB.
2. The term "reliable conversation" is used as a subjective measure of quality, and does not relate to any definition of quality issued by the CTIA/PCIA TTY Forum.
3. Signal Strength deemed "good" ranged from -65dBm to -80dBm.
4. Due to safety concerns, Cellular Product Technologies does not recommend the use of a TTY while driving a motor vehicle.
5. Samples of 510 characters were received by these devices, the printouts or displayed characters were transposed and scored using the Score Application.
6. FACCH (Fast Associated Control Channel) messages include; mobile power level change, handoff, MAHO RSSI request, timing adjustments.

# Cellular Product Technologies, LLC

## Field Test Results

### Page 1

| Test Date | Time | Direction | TX Rate | Test Type | Format | Vocoder | Phone | CER | Total | Correct | Changed | Missing | Added |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 7, 1998 | 5:53 PM | Mobile to Land | Full Rate | Stationary | AMPS | N.A. | Phone "A" | 0.00% | 4164 | 4164 | 0 | 0 | 3 |
| July 8, 1998 | 12:44 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "A" | 5.00% | 4164 | 3956 | 116 | 92 | 91 |
| July 8, 1998 | 1:10 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "A" | 2.28% | 4164 | 4069 | 60 | 35 | 25 |
| July 8, 1998 | 1:37 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "B" | 2.86% | 4164 | 4045 | 80 | 39 | 17 |
| July 8, 1998 | 1:50 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "B" | 2.07% | 4164 | 4078 | 57 | 29 | 10 |
| July 8, 1998 | 2:12 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "A" | 1.90% | 4164 | 4085 | 55 | 24 | 17 |
| July 8, 1998 | 4:11 PM | Mobile to Land | Full Rate | Driving | IS-136 | ACELP | Phone "A" | 2.47% | 4164 | 4061 | 46 | 57 | 46 |
| July 8, 1998 | 4:44 PM | Mobile to Land | Full Rate | Driving | IS-136 | ACELP | Phone "B" | 2.76% | 4164 | 4049 | 85 | 30 | 14 |
| July 8, 1998 | 5:05 PM | Mobile to Land | Full Rate | Driving | IS-136 | ACELP | Phone "A" | 3.41% | 4164 | 4022 | 57 | 85 | 82 |
| July 8, 1998 | 5:33 PM | Mobile to Land | Full Rate | Driving | IS-136 | ACELP | Phone "B" | 4.61% | 4164 | 3972 | 92 | 100 | 84 |
| July 9, 1998 | 2:55 PM | Mobile to Land | Half Rate | Stationary | IS-136 | ACELP | Phone "A" | 1.03% | 4164 | 4121 | 34 | 9 | 3 |
| July 9, 1998 | 3:48 PM | Mobile to Land | Half Rate | Stationary | IS-136 | ACELP | Phone "B" | 0.96% | 4164 | 4124 | 34 | 6 | 2 |
| July 9, 1998 | 4:20 PM | Mobile to Land | Half Rate | Stationary | IS-136 | ACELP | Phone "B" | 1.75% | 4164 | 4091 | 55 | 18 | 3 |
| July 9, 1998 | 5:00 PM | Mobile to Land | Half Rate | Stationary | IS-136 | ACELP | Phone "A" | 0.77% | 4164 | 4132 | 27 | 5 | 1 |
| July 9, 1998 | 5:45 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "A" | 1.32% | 4164 | 4109 | 45 | 10 | 3 |
| July 9, 1998 | 6:15 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "B" | 3.53% | 4164 | 4017 | 131 | 16 | 8 |
| July 13, 1998 | 11:42 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "B" | 1.68% | 4164 | 4094 | 61 | 9 | 1 |
| July 13, 1998 | 12:15 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "B" | 1.54% | 4164 | 4100 | 43 | 21 | 1 |
| July 13, 1998 | 1:00 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "A" | 3.05% | 4164 | 4037 | 121 | 6 | 2 |
| July 13, 1998 | 1:30 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "B" | 4.42% | 4164 | 3980 | 82 | 102 | 86 |
| July 13, 1998 | 2:30 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "A" | 0.96% | 4164 | 4124 | 37 | 3 | 2 |
| July 13, 1998 | 3:15 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "A" | 0.84% | 4164 | 4129 | 26 | 9 | 3 |
| July 13, 1998 | 3:45 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "B" | 1.97% | 4164 | 4082 | 62 | 20 | 1 |
| July 13, 1998 | 4:30 PM | Mobile to Land | Half Rate | Freeway | IS-136 | ACELP | Phone "A" | 3.17% | 4164 | 4032 | 49 | 83 | 4 |

All Scripts are available for viewing at: http://www.cellulartty.com/Products/Data/16.html

# Cellular Product Technologies, LLC

## Field Test Results

### Page 2

| Test Date | Time | Direction | TX Rate | Test Type | Format | Vocoder | Phone | CER | Total | Correct | Changed | Missing | Added |
|-----------|------|-----------|---------|-----------|--------|---------|-------|-----|-------|---------|---------|---------|-------|
| July 15, 1998 | 3:49 PM | Land to Mobile | Half Rate | Stationary | IS-136 | ACELP | Phone "B" | 5.16% | 4164 | 3949 | 177 | 38 | 4 |
| July 15, 1998 | 4:25 PM | Land to Mobile | Half Rate | Stationary | IS-136 | ACELP | Phone "A" | 1.10% | 4164 | 4118 | 33 | 13 | 1 |
| July 15, 1998 | 5:12 PM | Land to Mobile | Half Rate | Driving | IS-136 | ACELP | Phone "A" | 2.11% | 4164 | 4076 | 63 | 25 | 8 |
| July 15, 1998 | 5:49 PM | Land to Mobile | Half Rate | Driving | IS-136 | ACELP | Phone "B" | 1.39% | 4164 | 4106 | 38 | 20 | 2 |
| July 16, 1998 | 2:30 PM | Mobile to Land | Half Rate | Stationary | IS-136 | ACELP | Phone "C" | 0.24% | 4164 | 4154 | 6 | 4 | 0 |
| July 16, 1998 | 3:30 PM | Mobile to Land | Half Rate | Stationary | IS-136 | ACELP | Phone "C" | 0.29% | 4164 | 4152 | 7 | 5 | 1 |
| July 16, 1998 | 4:15 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "C" | 1.10% | 4164 | 4118 | 38 | 8 | 4 |
| July 16, 1998 | 4:45 PM | Mobile to Land | Full Rate | Stationary | IS-136 | ACELP | Phone "C" | 0.22% | 4164 | 4155 | 6 | 3 | 0 |
| July 16, 1998 | 5:15 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "C" | 0.67% | 4164 | 4136 | 23 | 5 | 0 |
| July 16, 1998 | 6:00 PM | Mobile to Land | Half Rate | Driving | IS-136 | ACELP | Phone "C" | 0.17% | 4164 | 4157 | 5 | 2 | 0 |
| July 16, 1998 | 7:00 PM | Mobile to Land | Half Rate | Freeway | IS-136 | ACELP | Phone "C" | 3.39% | 4164 | 4023 | 47 | 94 | 12 |
| July 17, 1998 | 1:00 PM | Mobile to Mobile | Half Rate | Stationary | IS-136 | ACELP | "A" & "C" | 0.50% | 4164 | 4143 | 17 | 4 | 3 |

All Scripts are available for viewing at: http://www.cellulartty.com/Products/Data/16.html

# Cellular Product Technologies, LLC

## Field Test Results
### Page 3
### (Small Sample Tests)

| Test Date | Time | Direction | TX Rate | TTY | Format | Vocoder | Phone | CER | Total | Correct | Changed | Missing | Added |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 17, 1998 | 11:20 AM | Mobile to Land | Half Rate | Mobility | IS-136 | ACELP | Phone "C" | 1.18% | 510 | 504 | 5 | 1 | 0 |
| July 17, 1998 | 11:20 AM | Mobile to Land | Half Rate | Compact | IS-136 | ACELP | Phone "C" | 18.04% | 510 | 418 | 46 | 46 | 5 |
| July 17, 1998 | 11:30 AM | Mobile to Land | Half Rate | Mobility | IS-136 | ACELP | Phone "C" | 0.39% | 510 | 508 | 2 | 0 | 3 |
| July 17, 1998 | 11:30 AM | Mobile to Land | Half Rate | EZCom Pro | IS-136 | ACELP | Phone "C" | 23.14% | 510 | 392 | 55 | 63 | 5 |
| July 17, 1998 | 11:40 AM | Mobile to Land | Half Rate | Mobility | IS-136 | ACELP | Phone "C" | 0.00% | 510 | 510 | 0 | 0 | 0 |
| July 17, 1998 | 11:40 AM | Mobile to Land | Half Rate | Dialogue III | IS-136 | ACELP | Phone "C" | 2.35% | 510 | 498 | 7 | 5 | 1 |
| July 17, 1998 | 11:50 AM | Mobile to Land | Half Rate | Mobility | IS-136 | ACELP | Phone "C" | 0.78% | 510 | 506 | 3 | 1 | 0 |
| July 17, 1998 | 11:50 AM | Mobile to Land | Half Rate | Superprint | IS-136 | ACELP | Phone "C" | 8.24% | 510 | 468 | 19 | 23 | 0 |

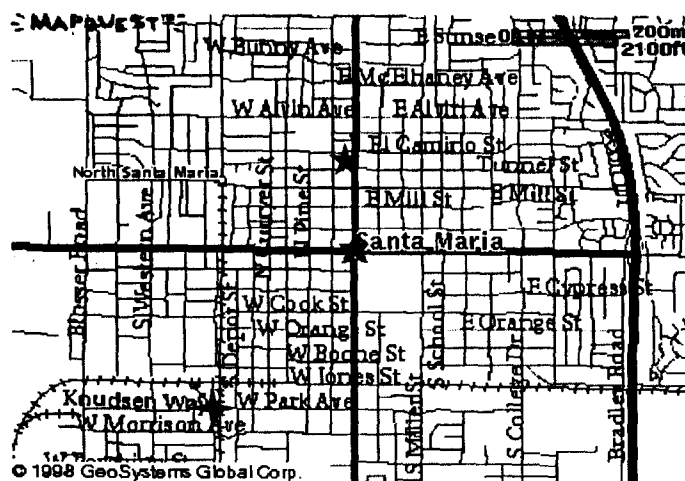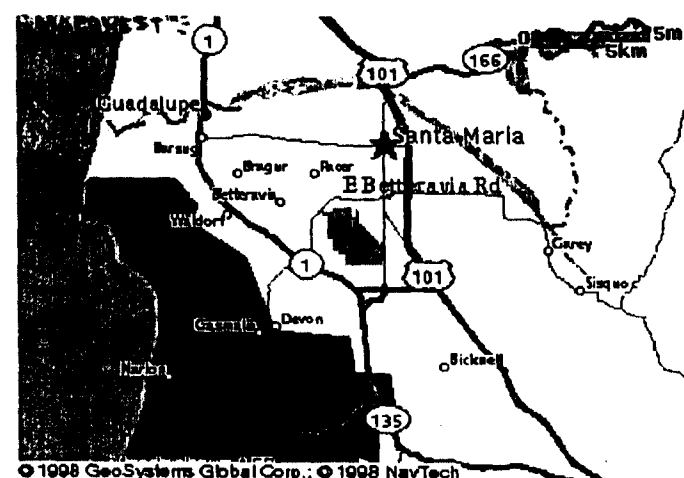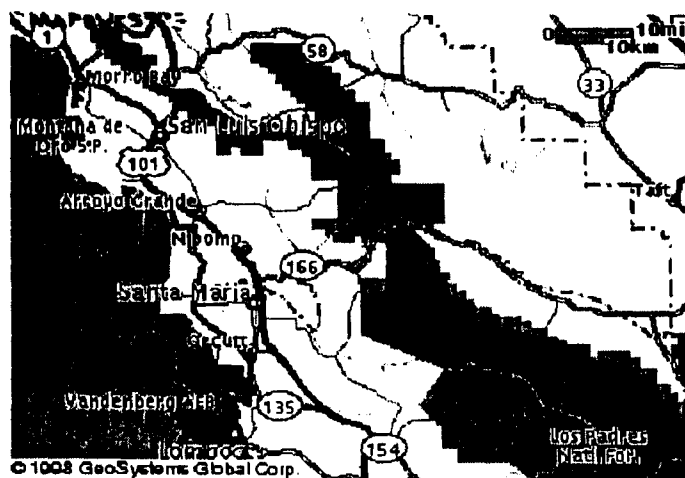All Scripts are available for viewing at: http://www.cellulartty.com/Products/Data/16.html

Note:
The Mobility TTY was used as a baseline to ensure the cellular channel was of reasonable quality.

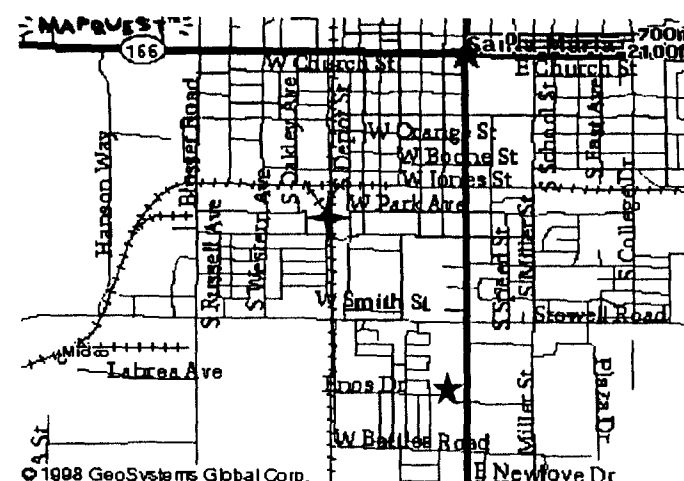# Cellular Product Technologies, LLC



Stationary Test Location

Drive Test Location

# Cellular Product Technologies, LLC

- Background on DVC™ Technology

  - CPT developed Digital Vocoder Compensating Technology (DVC™) to successfully pass FSK audio (used in TTY communications) over a digital cellular network.

  - DVC™ Compensation does not modify in any way the BAUDOT character set.

  - Voice Coders and Decoders (vocoders) used in IS-136 Digital Cellular Networks include IS-54 (VSELP), and IS-641 (ACELP).

  - Currently, most IS-136 systems in the U.S. only support ACELP vocoders.

  - Vocoders effect the FSK audio by "distorting" the FSK waveform.

  - The time domain is effected by adding "Pops" in amplitude thereby increasing the dynamic range of the FSK waveform.[1]

  - The frequency domain is not effected greatly, as no destructive harmonic byproducts are generated by the vocoder.[2]

Notes:
1. See Plots 1 and 3.
2. See Plots 2 and 4.

# Cellular Product Technologies, LLC

- Background on DVC™ Technology (continued)
  - The key to successful TTY communication over an IS-136 TDMA network, is the FSK receiver in the TTY.
    - Unfortunately, there is no standard for the performance of a TTY receiver.
    - The TTYs currently in homes, offices and emergency facilities have FSK receivers varying in performance.
  - Since TTY Devices with varying grades of FSK receivers are used throughout the world, it is important to compensate as much as possible (on the transmit side) to make-up for the shortcomings in the receivers of those TTYs.
  - How CPT resolves the "Vocoder Problem".
    - Transmit Side
      - DVC™ signal processing techniques applied to the transmitted FSK audio help the FSK tones pass through the vocoder.
      - Introducing inter-character delays to decreases the CER.
    - Receive Side
      - The Mobility™ TTY has a high quality FSK receiver with a dynamic range greater than 49dB.

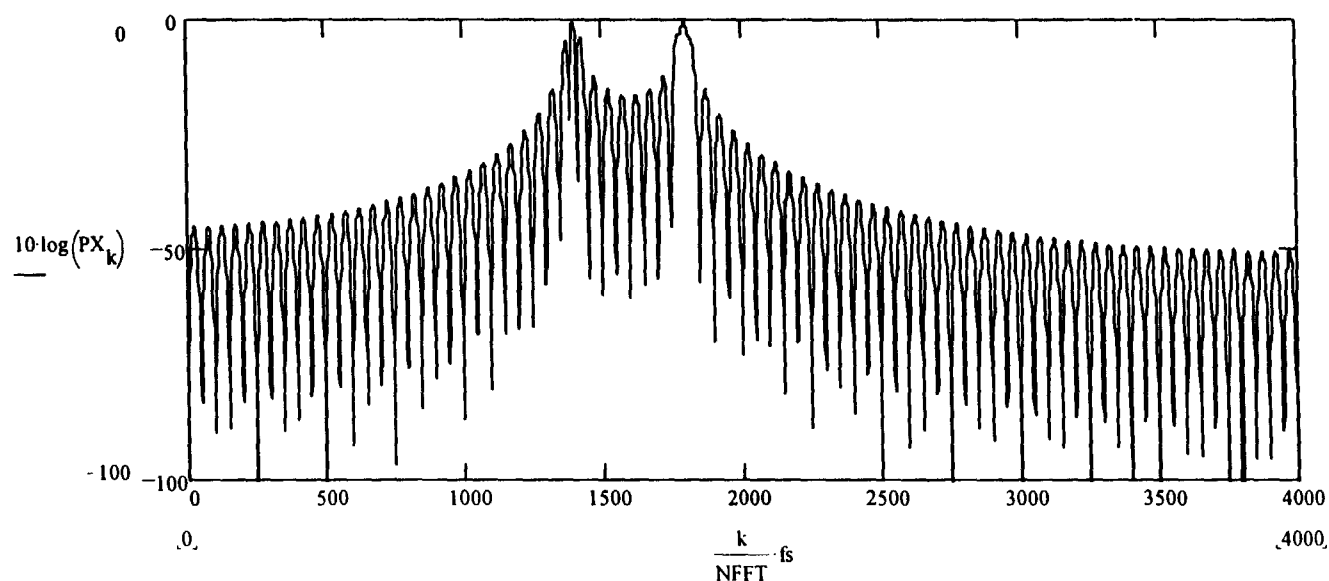# Cellular Product Technologies, LLC

## Plot #1

Time Domain Plot - 100mS in duration consisting of five 20mS periods,
Frequency Shifting (non-coherent FSK modulation) between 1400 Hertz and
1800 Hertz. This plot is a baseline for how FSK tones look "normally".
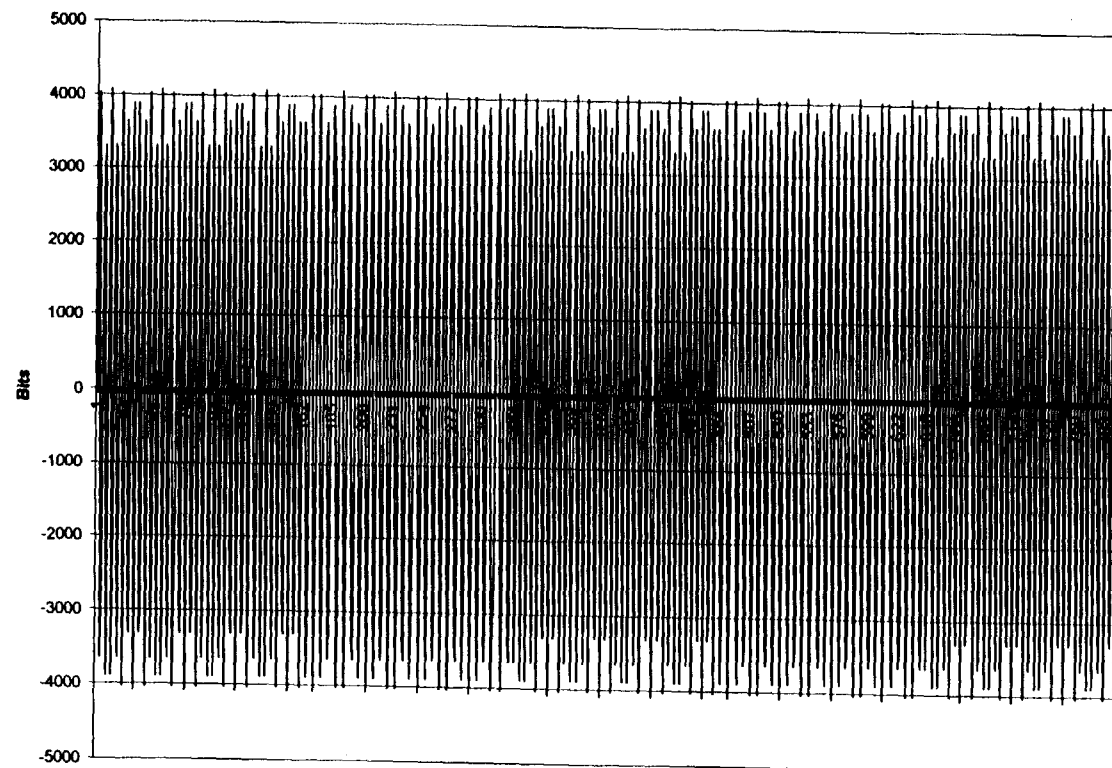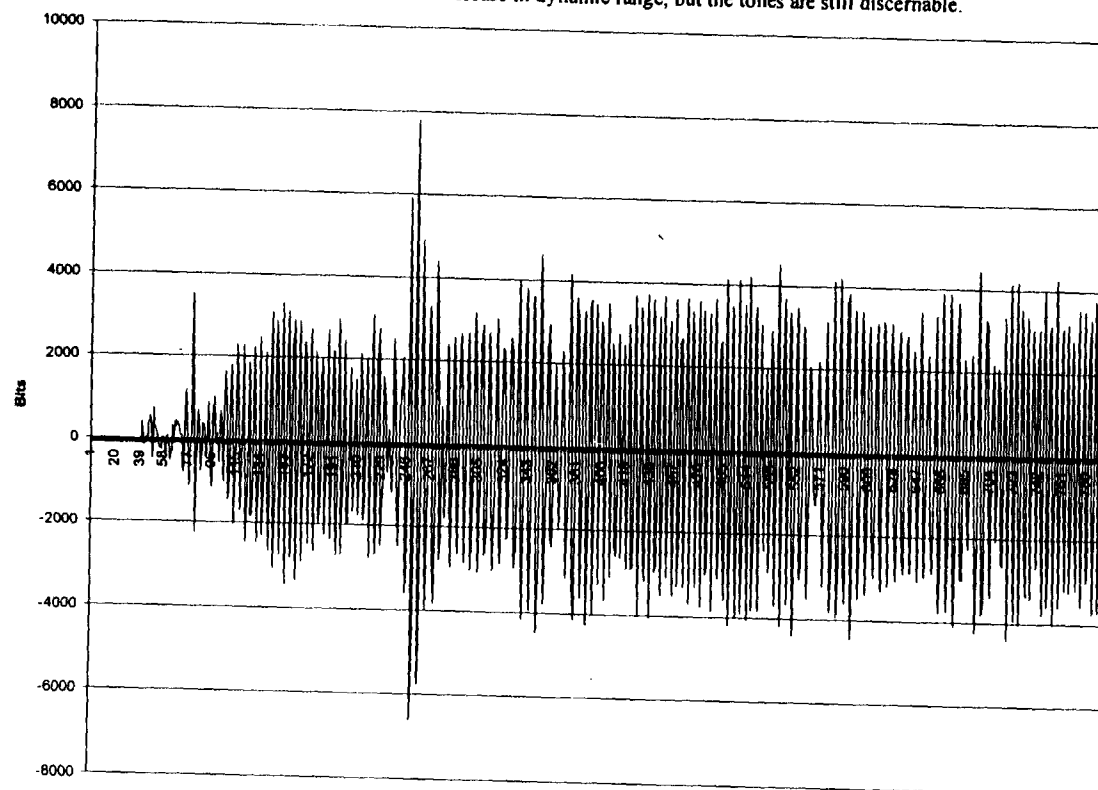
# Cellular Product Technologies, LLC

## Plot #2

Frequency Domain Plot - 800 samples at a rate of 8KHz (100mS), consisting of
five 20mS periods, Frequency Shifting (non-coherent FSK modulation) between
1400 Hertz and 1800 Hertz. This plot is a baseline for how the frequency domain
looks "normally".

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## Plot #3

Time domain plot, 100mS in duration consisting of five 20mS periods,
Frequency Shifting (non-coherent FSK modulation) between 1400 Hertz and
1800 Hertz. This plot has the ACELP vocoder engaged, and shows the "pops"
added. There is an increase in dynamic range, but the tones are still discernable.



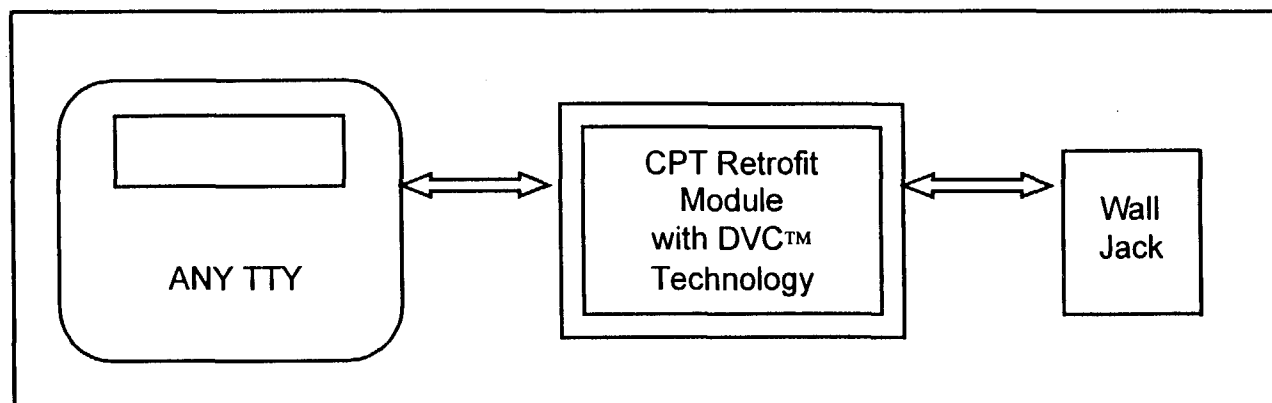7/18/98

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## Plot #4

Frequency Domain Plot – 800 samples at a rate of 8KHz (100mS), consisting of
five 20mS periods, Frequency Shifting (non-coherent FSK modulation) between
1400 Hertz and 1800 Hertz. This plot has the ACELP vocoder engaged. The
purpose of this plot is to show the frequency spectrum is only minimally
corrupted by the vocoder.
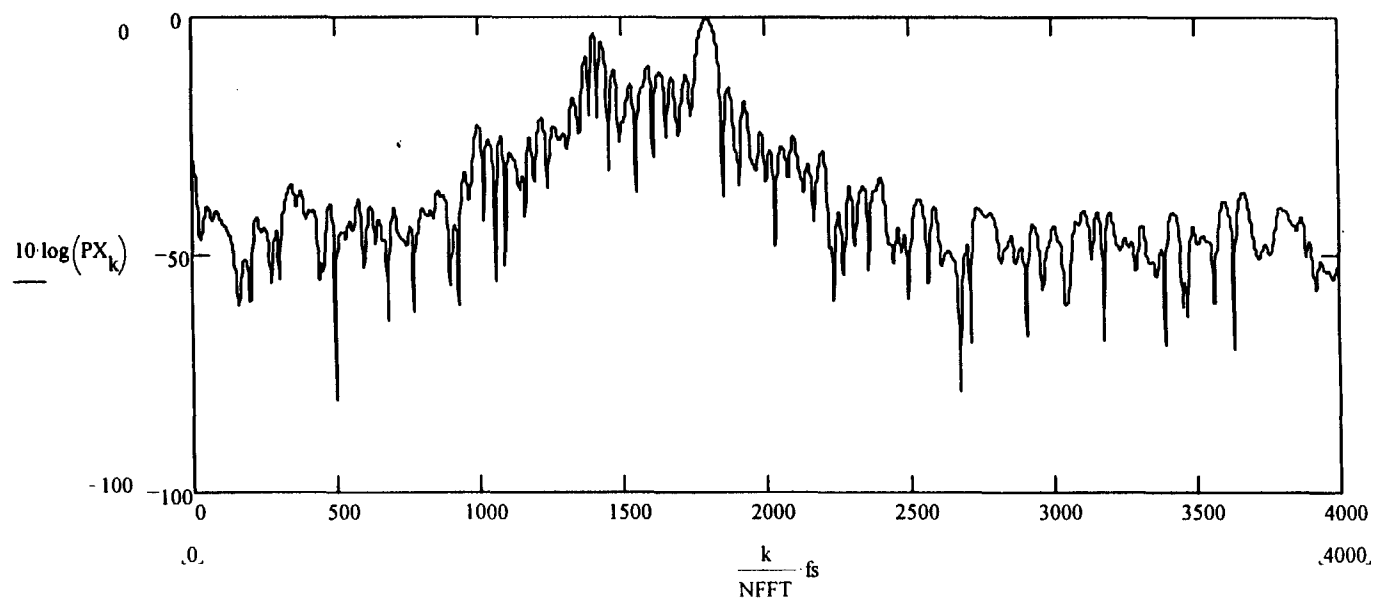
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⁍ **Products for existing TTYs**

– CPT is developing a "retrofit module" for use with existing TTYs. The "retrofit module" will be installed between the TTY and the wall jack, and will contain:

• Transmit Side

    – Receive FSK tones from the local TTY.

    – Interpret and re-generate the TTY tones applying DVC™ technology.

• Receive Side

    – Incorporate a high quality FSK receiver with a dynamic range greater than 49dB.

    – Receive FSK tones from the remote TTY

    – Re-generate the tones, and send to the local TTY.



7/18/98        TTY Forum, July 21 1998     *Recommends 2.5 mm between portable TTY to cellular*     24

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